
**Railway applications — Concrete
sleepers and bearers for track —**

**Part 1:
General requirements**

*Applications ferroviaires — Traverses et supports en béton pour la
voie —*

Partie 1: Exigences générales

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 269, *Railway applications*, Subcommittee SC 1, *Infrastructure*.

This document is used in conjunction with ISO 22480-2.

A list of all parts in the ISO 22480 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document covers the general requirements for concrete sleepers and bearers.

Concrete sleepers and bearers are safety critical components for railway applications. They are not covered by any other International Standards for structural concrete.

As safety critical components, an agreement is needed between the purchaser and the supplier to perform sleeper design and manufacture as well as to operate a factory quality system.

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Railway applications — Concrete sleepers and bearers for track —

Part 1: General requirements

1 Scope

This document defines technical criteria and control procedures which need to be satisfied by the constituent materials and the finished concrete sleepers and bearers, i.e. precast concrete sleepers, twin-block reinforced sleepers, bearers for switches and crossings, and special elements for railway tracks.

This document defines mechanical tests which provide assurance of the capability of sleepers or bearers to resist repetitive loading and provide sufficient durability. In addition, it places controls on manufacturing processes and tests to ensure that the concrete will not suffer degradation in service through chemical reaction and frost damage.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22480-2, *Railway applications — Concrete sleepers and bearers for track — Part 2: Prestressed monoblock sleepers*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

purchaser

body responsible for acquiring the product on the end user's behalf

3.2

supplier

body responsible for the use of this document in response to the *purchaser's* (3.1) requirement, and for requirements which apply to the *manufacturer* (3.3)

**3.3
manufacturer**

producer
body producing concrete *sleeper* (3.4) and *bearer* (3.5) products

**3.4
sleeper**

transverse component of the track which controls the rail gauge, inclination and which transmits loads from the rail to the ballast or other sleeper support

**3.5
bearer**

transverse component of switches and crossings which controls rail gauge, inclination and the relative geometry of two or more stretches of running rails and different pieces of special track work, and transmits loads from the rails to the ballast or other bearer support

**3.6
bending moment**

internal moment created by external loads applied to the concrete *sleeper* (3.4) or *bearer* (3.5) which produces tension and compression in the element

**3.7
positive bending moment**

bending moment (3.6) which produces tension or reduces compression at the bottom of a cross-section of a concrete *sleeper* (3.4) or *bearer* (3.5)

**3.8
negative bending moment**

bending moment (3.6) which produces tension or reduces compression at the top of a cross-section of a concrete *sleeper* (3.4) or *bearer* (3.5)

**3.9
rail seat**

area on which a running rail rests

**3.10
rail seat area**

rail seat (3.9) and the immediate area around the fastening system

**3.11
twin-block reinforced sleeper**

sleeper (3.4) in which two reinforced concrete blocks are connected by a steel connecting bar

**3.12
test load**

load applied during testing

**3.13
bending crack**

partial split in concrete due to an external *bending moment* (3.6)

**3.14
residual crack**

bending crack (3.13) measured during a test after an external *bending moment* (3.6) has been applied and has been removed

3.15**first crack**

crack under loading irrespective of width which originates in the tensile face of the concrete *sleeper* (3.4) and *bearer* (3.5) extending to a minimum depth of 15 mm on one side or other of the concrete sleeper and bearer and which increases in width (at the depth of 15 mm) with further application of load

Note 1 to entry: The crack under loading is a *bending crack* (3.13) measured during a test with an external *bending moment* (3.6) applied.

3.16**minimum concrete cover**

minimum cover given by the nominal cover reduced by the production tolerance

3.17**design approval test**

test on a concrete *sleeper* (3.4) or *bearer* (3.5) or part of a concrete sleeper or bearer to demonstrate compliance with the acceptance criteria

3.18**routine test**

test carried out on a concrete *sleeper* (3.4) or *bearer* (3.5), as a part of the manufacturing quality control process

4 Symbols and abbreviated terms

Symbol	Description	Unit
F_{c0}	initial reference load for positive bending test at centre section	kN
F_{c0n}	initial reference load for negative bending test at centre section	kN
F_{cr}	test load which produces first crack formation at the centre section during positive bending test at centre section; load preceding the load for which a crack width measured under load, at 15 mm depth, is equal or higher than 0,02 mm on one of the faces	kN
F_{crn}	test load which produces first crack formation at the centre section during negative bending test at centre section; load preceding the first negative test load for which a crack width measured under load, at 15 mm depth, is equal or higher than 0,02 mm on one of the faces	kN
F_{r0}	initial reference load for positive bending test at rail seat section	kN
$F_{r0,05}$	test load for which a crack width of 0,05 mm at the bottom of rail seat section persists after removal of the load during positive bending test at rail seat; load preceding the test load, for which a residual crack width measured at 15 mm depth, persisting after removal of the load and is equal or higher than 0,06 mm on one of the faces	kN
$F_{r0,5}$	test load for which a crack width of 0,5 mm at the bottom of the rail seat section persists after removal of the load; load preceding the first positive test load, for which a residual crack width measured at 15 mm depth persists after removal of the load and is equal or higher than 0,51 mm on one of the faces	kN
F_{r0n}	initial reference load for negative bending test at rail seat section	kN
F_{rB}	maximum test load which cannot be increased during positive bending test at rail seat section	kN
F_{rr}	test load which produces first crack formation at the rail seat section during positive bending test at rail seat; load preceding the load for which a crack width measured under load, at 15 mm depth, is equal or higher than 0,02 mm on one of the faces	kN
k_{1d}	coefficient used to calculate the acceptance criterion for test load $F_{r0,05}$ in the cyclic test	—
k_{1s}	coefficient used to calculate the acceptance criterion for test load $F_{r0,05}$ in the static test	—

k_{2d}	coefficient used to calculate the acceptance criterion for test loads $F_{r0,5}$ or F_{rB} in the cyclic test	—
k_{2s}	coefficient used to calculate the acceptance criterion for test load F_{rB} in the static test	—
k_3	coefficient used to calculate the acceptance criterion for test load F_{rB} in the fatigue test	—
k_t	coefficient used to calculate the acceptance criteria for test loads F_{rp} , F_{cr} and F_{crn} in static tests, taking into account the age of the sleeper or bearer at the time of testing (see Annex A)	—
M_0	reference test bending moment for design approval tests and routine tests	kNm
$M_{0,c,neg}$	reference test bending moment for the negative bending test at the centre section	kNm
$M_{0,c,pos}$	reference test bending moment for the positive bending test at the centre section	kNm
$M_{0,r,pos}$	reference test bending moment for the positive bending test at the rail seat section	kNm
M_{cr}	bending capacity for first crack formation of the prestressed concrete cross-section, calculated for the age of the sleeper at the time of testing	kNm
$M_{cr,c,neg}$	bending capacity for first crack formation for a negative bending moment at the sleeper centre	kNm
$M_{cr,c,pos}$	bending capacity for first crack formation for a positive bending moment at the sleeper centre	kNm
$M_{cr,r,pos}$	bending capacity for first crack formation for a positive bending moment at the rail seat	kNm
M_k	characteristic bending moment which is the bending moment due to dynamic rail seat load P_k	kNm
$M_{k,c,neg}$	characteristic negative bending moment at centre section which is the negative bending moment at centre section due to dynamic rail seat load P_k	kNm
$M_{k,c,pos}$	characteristic positive bending moment at centre section which is the positive bending moment at centre section due to dynamic rail seat load P_k	kNm
$M_{k,r,neg}$	characteristic negative bending moment at rail seat section which is the negative bending moment at rail seat due to dynamic rail seat load P_k	kNm
$M_{k,r,pos}$	characteristic positive bending moment at rail seat section, which is the positive bending moment at rail seat due to dynamic rail seat load P_k	kNm
P_k	dynamic rail seat load which is the characteristic load on a rail seat of the sleeper for normal service dynamic loading taking into account traffic demand and maintenance conditions	kN
$q_{max,fat}$	coefficient used to calculate the upper test load for the fatigue test	—

5 Determination of test loads

5.1 General

The track system is an assembly of transverse sleepers or bearers secured to the rails by means of fastening systems and supported by ballast or other support. It is characterized by the track gauge, the rail profile, the inclination of the rails and the spacing of the concrete sleepers or bearers.

5.2 Loads for sleepers and bearers in track

5.2.1 Loads

The track is subjected to repeated loads in three different directions, generally applied simultaneously:

- a) vertical loads from axle load and service conditions;
- b) lateral loads from guiding forces;

c) longitudinal loads from acceleration and braking, thermal stresses in continuous welded rail, etc.

As rail traffic loads can vary in a large range, three different load levels shall be taken into account to define technical requirements for sleepers and bearers:

- normal service dynamic loads due to rail traffic under regular maintenance conditions for track and rolling stock;
- exceptional loads can occur repeatedly due to poor quality of rolling stock or track (e.g. impact loads due to large wheel flats, railhead corrugation, frozen ballast in combination with uplift at the sleeper centre);
- accidental loads (e.g. impact load due to derailment) occur once during service life, i.e. the sleepers or bearers are usually replaced after being exposed to accidental loads.

At normal service dynamic and exceptional loads levels on sleepers and bearers, the track shall retain its geometry including gauge, top level and alignment and its durability. Durability is no longer required after accidental load actuation.

5.2.2 Load distribution

The assembled rail, fastening system and concrete sleepers and bearers on ballast or other support shall be considered as a beam on a continuous elastic support.

The moment of inertia of the rail profile, the spacing of the concrete sleepers and bearers and the elasticity of the whole assembly on its support, have an influence on the longitudinal distribution of the vertical loads applied to the rail. As a result, at normal service dynamic load level, the rail seat load applied to the concrete element is only a proportion of the wheel load.

For impact loads at the exceptional or accidental load level, the effect of load distribution by the rail can be reduced or even negligible.

5.2.3 Characteristic bending moments

The distributed loads generate bending moments in the sleepers and bearers. A characteristic value of bending moments, produced by characteristic dynamic rail seat loads, is used in this document to establish the technical requirements for sleepers and bearers.

The characteristic bending moments for sleepers and bearers shall be determined by the purchaser taking into account static wheel load and wheel load fluctuation, as well as the normal dynamic influence of wheel and track irregularities. This can be done by calculation or measurement in track.

The design of sleepers and bearers shall be based on the characteristic bending moments.

5.3 Test loads

5.3.1 General

Bending tests for concrete sleepers and bearers shall be undertaken for one of the following purposes:

- a) method A: verification of bending capacities as predicted by the design calculation;
- b) method B: verification of minimum performance requirements for loads in track.

The purchaser shall define the method to be used in order to ensure that the required performance is fulfilled at all load levels.

5.3.2 Method A: verification of bending capacities

Sleepers and bearers shall be tested in order to demonstrate compliance with the product design.

The bending capacities for the first crack formation, M_{cr} , shall be used as reference test bending moments, M_0 , for the calculation of test loads and acceptance criteria in accordance with ISO 22480-2. Any relevant regional or national standard may be used to predict the bending capacity for the first crack formation, M_{cr} , of the sleeper or bearer (detailed information is given in [Annex B](#)).

The calculation of the bending capacity for the first crack formation shall take into account:

- a) material properties;
- b) dimensions;
- c) prestressing force or reinforcement;
- d) age of the sleeper at the moment of testing.

5.3.3 Method B: verification of minimum performance requirements

Sleepers and bearers shall be tested in order to demonstrate compliance with the minimum performance requirements defined by the purchaser. The test loads and acceptance criteria are based on characteristic bending moments, M_k , and additional requirements for exceptional and accidental loads based on measurement in track (detailed information is given in [Annex C](#)).

The age of the sleeper or bearer at the moment of testing is taken into account by a coefficient k_t used to determine the acceptance criterion for first crack formation.

Impact coefficients k_1 , k_2 and k_3 are used to determine the acceptance criteria for the performance tests at the different load levels.

The characteristic bending moments, M_k , shall be used as reference test bending moments, M_0 , for the calculation of test loads and acceptance criteria in accordance with ISO 22480-2.

6 Data to be supplied

6.1 General

The data required for production and testing of sleepers and bearers shall be supplied by the purchaser or the supplier depending on the design process and the test method required by the purchaser.

The purchaser shall define which method shall be used.

6.2 Data to be supplied by the purchaser

The purchaser shall specify at least the following data:

- a) relevant regional or national standards to be taken into account;
- b) required tests and choice of options for design approval;
- c) age of the sleeper or bearer used for design approval and routine tests;
- d) in case of method A; bending capacities $M_{cr,r,pos}$, $M_{cr,c,neg}$ and – if required – $M_{cr,c,pos}$;
- e) in case of method B; characteristic bending moments $M_{k,r,pos}$, $M_{k,c,neg}$ and – if required – $M_{k,r,neg}$ and $M_{k,c,pos}$;
- f) depending on tests required by the purchaser, the coefficients k_t , k_{1s} , k_{2s} , k_{1d} , k_{2d} , k_3 and $q_{max,fat}$;
- g) drawings and specifications for:
 - 1) main dimensions (see [Table 1](#)) or detailed sleeper geometry, if specified by the purchaser;

- 2) if specified by the purchaser: prestressing system (including material strength, number and position of prestressing elements, pressing force, indentation of prestressing wires, if present and anchorage devices, if any);
- 3) if specified by the purchaser: material characteristics of concrete and additional reinforcement;
- 4) fastening system interface, rail profile and geometric layout;
- 5) particular tolerances (if deviating from [8.1.1](#), see [Table 1](#));
- 6) if required, conductor rail insulator supports;
- h) if required, absolute maximum and minimum weight of the concrete sleeper and bearer (kilograms per sleeper or kg/m);
- i) any additional technical specification, e.g. electrical insulation;
- j) if required, storage conditions of sleepers for testing.

6.3 Data to be provided by the supplier

6.3.1 Before the design approval tests

The supplier shall specify the following data:

- a) detailed production drawing of the sleeper or bearer including the prestressing system or reinforcement;
- b) characteristics of materials;
- c) in case of method B: coefficient k_t for each section, to be approved by the purchaser;
- d) description of manufacturing process;
- e) description of the prestressing system including anchoring system (if any):
 - 1) for bonded anchoring systems: the adherence specification of the tendons, for example indentation;
 - 2) for anchor elements inside the sleeper: characteristics of chemical, dimensional and mechanical tolerances.

6.3.2 After the design approval tests

The supplier shall specify the design approval test report.

6.3.3 Prior to start-up of production

The supplier shall specify:

- a) all data required in [Clause 10](#);
- b) the production file for manufacturing data as defined in [8.2.2](#).

7 Materials

7.1 General requirements

All materials shall comply with relevant International Standards. If no International Standards exist, materials shall comply with appropriate regional or national standards. Materials other than those specified in 7.2 to 7.7 shall only be used with the agreement of the purchaser.

Great care shall be exercised in the selection of materials to ensure the long-term durability of the concrete. Consideration shall be given to the requirements for freeze-thaw resistance, water absorption and abrasion resistance.

Where aggregates contain varieties of silica susceptible to attack by alkalis (Na_2O and K_2O originating from cement or other sources) and if the concrete is exposed to humid conditions, precautions in the choice of constituents shall be taken. Typical precautions are stated in the NOTE. Other precautions can include provisions which are valid where the concrete is used, taking into account previous long-term experience using the particular combination of cement and aggregate and agreed by the purchaser.

The supplier shall provide a document including all precautions about alkali silica reaction for agreement by the purchaser.

NOTE Typical precaution is to apply one of the following:

- a) use of low-alkali cement with total alkali content, stated as Na_2O equivalent, less than or equal to 0,60 %;
- b) use of additions allowed by relevant regional or national standards, where they exist;
- c) the total mass of reactive alkalis in the concrete not exceeding $3,0 \text{ kg/m}^3$ or as per relevant regional or national standards, where they exist;
- d) use of only non-reactive aggregates, regularly confirmed by ex-quarry petrographic analysis (see 7.3 and the total mass of reactive alkalis in the concrete not exceeding $3,5 \text{ kg/m}^3$.)

7.2 Cement

Cement shall comply with relevant regional or national standards (see Annex D).

Use of Portland cement with minimum characteristic strength of 42,5 MPa at 28 days and complying with relevant regional or national standards is recommended (see Annex D).

Cement other than type Portland cement shall only be used if the durability of the sleepers can be demonstrated and approval is obtained from the purchaser.

Content of SO_3 in concrete shall be less than 4 % in mass of cement.

The total alkali content expressed as Na_2O equivalent shall be as per relevant regional or national standards (see Annex D).

The manufacturer shall obtain certificates from the cement supplier detailing the chemical and physical properties of the cement at a sufficient frequency to comply with the quality plan.

7.3 Aggregates

Aggregates shall comply with relevant regional or national standards.

The manufacturer shall supply the following information to the purchaser concerning aggregates to be used:

- a) grading curve;

- b) petrographic analysis including:
 - 1) susceptibility to alkaline-aggregate reaction;
 - 2) presence of particles leading to poor abrasion resistance;
 - 3) presence of absorbent particles leading to frost damage;
- c) chemical analysis including:
 - 1) maximum chloride content;
 - 2) maximum sulphate content;
 - 3) maximum organic material content.

The petrographic analysis shall be carried out at least every two years and every time the source (quarry face or strata) changes.

Aggregates not occurring naturally shall only be used with the agreement of the purchaser.

The maximum size of aggregates shall be determined taking into account the minimum cover and minimum spacing of reinforcement.

The properties of the fine aggregates shall not allow unacceptable abrasion of the concrete element on the parts in contact with the ballast or on the rail seat [see 9.6 d)].

Use of recycled aggregates is permitted, subject to the agreement of the purchaser, when the supplier can provide evidence of origin and suitable quality of materials.

7.4 Mixing water

In general, potable water is suitable for concrete.

If non-potable water is used, it shall be tested according to relevant regional or national standards.

7.5 Admixtures

Admixtures shall comply with relevant regional or national standards.

Calcium chloride setting acceleration admixtures shall not be used.

The supplier shall offer a solution for durability, to be approved by the purchaser.

7.6 Concrete

7.6.1 Material requirements

The concrete shall generally comply with relevant regional or national standards and the following requirements:

- a) minimum characteristic compressive strength shall be:
 - 45 MPa when measured on a 150 mm diameter and 300 mm high cylinder; or
 - 55 MPa when measured on a 150 mm cube;
 unless otherwise required by the purchaser;
- b) water/cement ratio shall be less than 0,45 in mass;
- c) minimum cement or equivalent binder content shall be 300 kg/m³;

d) compaction of the concrete shall be sufficient to minimize water penetration (see 9.6).

7.6.2 Information to be provided by the supplier

The supplier shall submit to the purchaser the following information about the concrete:

- a) description of the constituent materials including origin, composition, shape and size;
- b) mix design;
- c) full description of the production process for the concrete including cold weather working, and the storage and measurement of materials;
- d) technical report on the following requirements:
 - 1) alkali content according to national standards;
 - 2) design test on the concrete, according to 9.4;
 - 3) the following tests if required:
 - a) freeze–thaw resistance [see 9.6 a)];
 - b) porosity (see Annex E);
 - c) resistance to chloride penetration [see 9.6 c)];
 - d) abrasion properties of fine aggregates [see 9.6 d)].

7.6.3 Changes for the material and processes

No change shall be made to the materials and processes used without the agreement of the purchaser.

7.7 Steel

7.7.1 Prestressing tendons

Prestressing tendons shall consist of wires, strands or bars according to the relevant regional or national standards.

7.7.2 Reinforcing steel

Reinforcing steel shall comply with relevant regional or national standards and provisions valid in the place of use. It may be smooth, indented or deformed and shall be of weldable quality where required for reinforcement assembly. Welds shall only be used to aid assembly and shall not affect the fatigue performance of the sleeper.

7.7.3 Steel connecting bar for twin-block sleepers

7.7.3.1 Chemical composition

The chemical composition of the steel shall be within the following limits:

- C: between 0,28 % and 0,80 %;
- Mn: between 0,45 % and 1,40 %;
- P: less than or equal to 0,08 %;
- S: less than or equal to 0,08 %;

— Si: less than or equal to 0,50 %.

7.7.3.2 Mechanical properties

The mechanical properties (conventional yield strength at 0,2 % tensile strain, percentage elongation at fracture) shall be maintained within the following limits:

- a) tensile strength (R_m) in MPa: $550 \leq R_m \leq 1\ 030$;
- b) relationship between percentage elongation and yield strength (R_p) when tested in accordance with ISO 6892-1:
 - for $R_p \geq 400$ MPa, $A \geq 8$ %;
 - for 350 MPa $\leq R_p < 400$ MPa, $A \geq 14$ %;
 where A is the minimum percentage elongation;
- c) Brinell hardness (HBW) to be $160 \leq HBW \leq 300$, when tested according to ISO 6506-1.

7.8 Embedded components

The fastening inserts are defined by the fastening system used by the purchaser and shall comply with the technical specifications and drawings of the system.

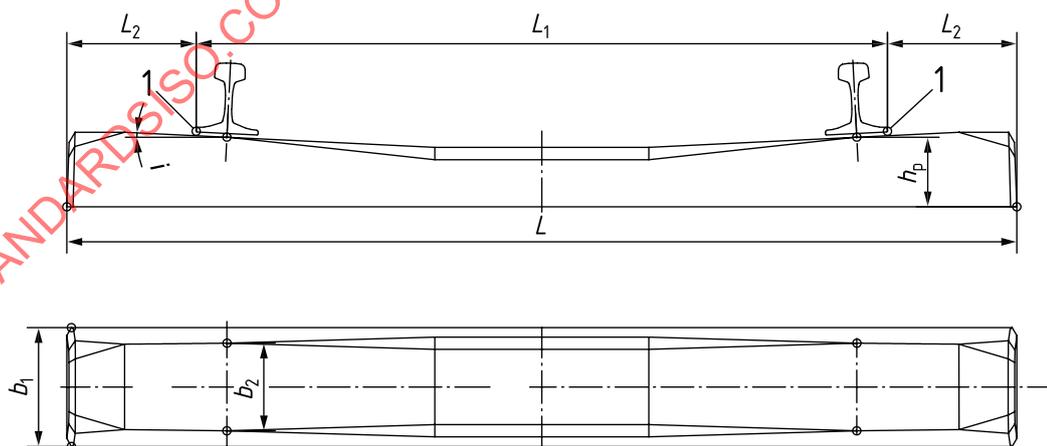
The surface of these components in contact with concrete shall be free of mud, oil, loose rust and scale or other contamination.

8 General requirements

8.1 Design

8.1.1 Geometrical design

Typical shapes of concrete sleepers and bearers are shown in [Figures 1, 2 and 3](#).

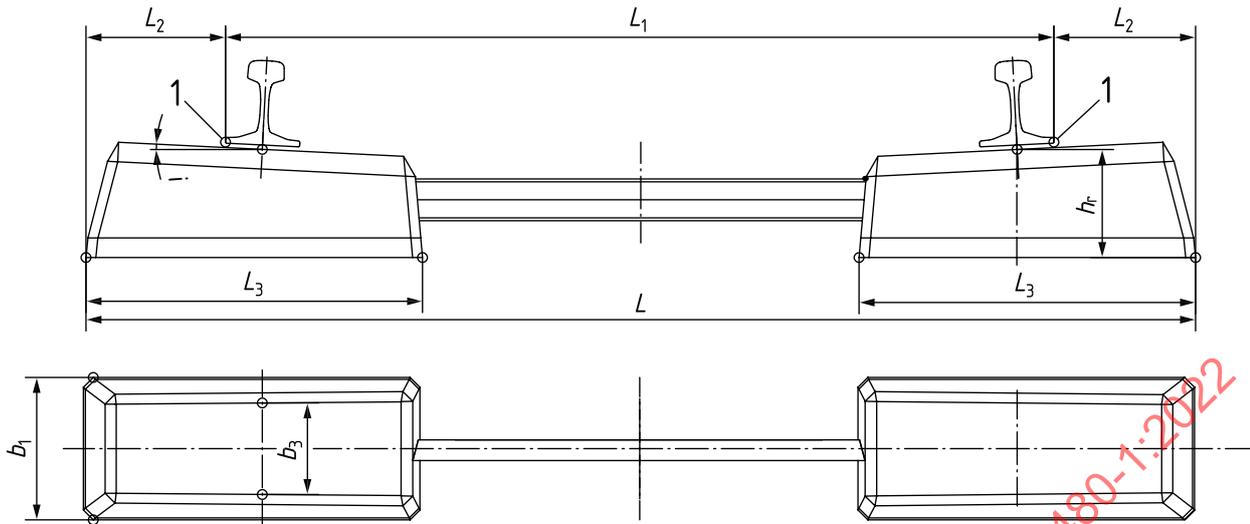


Key

1 gauge points

NOTE See [Table 1](#).

Figure 1 — Typical prestressed monoblock sleeper

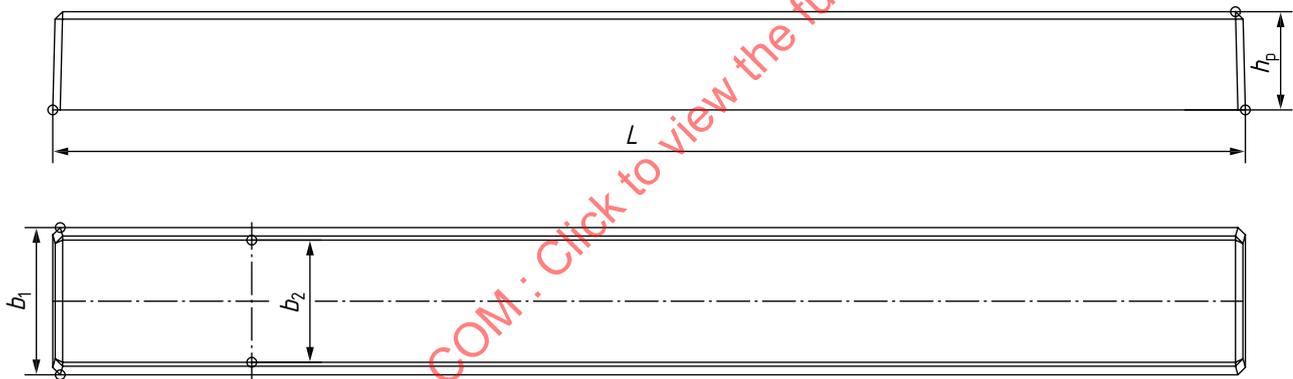


Key

1 gauge points

NOTE See Table 1.

Figure 2 — Typical twin-block reinforced sleeper



NOTE See Table 1.

Figure 3 — Typical prestressed concrete bearer

The values of the main dimensions shall be determined by the purchaser.

The maximum tolerances specified in Table 1 apply to ballasted track and can be varied by the purchaser in the case of special requirements such as dedicated concrete elements for ballastless track or use of a sleeper laying machine, etc.

Table 1 — Maximum tolerances

Symbols	Description	Tolerances
L	overall length of the concrete element	± 10 mm
b_1	maximum bottom width of the concrete element	± 5 mm
b_2	top width of the concrete element	± 5 mm
b_3	top width of the concrete element at the axis of the rail seat	± 5 mm

^a The purchaser shall indicate if all or part of the fastening system is included in the mass of the concrete element.

Table 1 (continued)

Symbols	Description	Tolerances
h_r	depth at any position along the total length of the reinforced concrete element measured in accordance with the quality plan	$\begin{pmatrix} +10 \\ -3 \end{pmatrix}$ mm
h_p	depth at any position along the total length of the prestressed concrete element measured in accordance with the quality plan	$\begin{pmatrix} +5 \\ -3 \end{pmatrix}$ mm
L_1	distance between gauge points taking into account the fastening system, the rail and the track gauge	± 2 mm
L_2	position of the gauge point with regard to the end of the concrete element	± 8 mm
L_3	total length of reinforced concrete block	± 8 mm
i	inclination of the rail seat (see Annex F)	$\pm 0,25^\circ$
f	planeness of each rail seat area: with regard to 2 points 150 mm apart	1 mm
T	relative twist between rail seats	
	for monoblock sleepers (see Annex F)	$0,5^\circ$
	for twin-block sleepers (see Annex F)	$0,8^\circ$
	from same track for concrete bearers (see Annex F)	$0,5^\circ$
m	mass of the sleeper (variation with regard to nominal weight) ^a	± 5 %

^a The purchaser shall indicate if all or part of the fastening system is included in the mass of the concrete element.

The design, dimensions and tolerances of the fastening system shall be defined by the purchaser.

The purchaser shall specify the minimum clearances between rail fastening component and reinforcement according to the fastening system to be used, and between reinforcement and connecting bar for twin-block sleepers.

8.1.2 Concrete cover

Unless there is an alternative agreement between the purchaser and the supplier, the minimum concrete cover for prestressing tendons shall be 30 mm from the bottom surface and 20 mm from the other surfaces except at the ends of sleepers and bearers.

The above-mentioned concrete cover requirements do not apply to the anchorage system of prestressed sleepers. For these anchorage systems, the manufacturer shall propose the concrete cover to apply in accordance with the purchaser.

The minimum concrete cover for reinforcing steels shall be 25 mm from the bottom surface and 15 mm for the rail seat area and 20 mm from the other surfaces, except for the end of spacing bars.

8.1.3 Prestressing system design

The supplier shall define all data in relation with the nominal prestressing force, nominal position of each tendon and anchorage system.

The vertical position of the centroid of the prestressing shall be within ± 3 mm of the nominal vertical position relative to the rail seat.

The vertical position of each individual prestressing tendon shall be within ± 6 mm of the nominal position relative to the rail seat.

The horizontal position of each individual prestressing tendon shall be within ± 6 mm of the nominal position relative to the sleeper axis.

The total initial prestressing force shall be applied within ± 5 % of the specified nominal force.

8.1.4 Reinforcing steel design

The supplier shall define all data in relation with the design of the reinforcing steel and nominal position in the concrete element.

The reinforcing steel shall be within ± 5 mm of the nominal position in all directions.

8.2 Manufacturing process

8.2.1 General requirements

Details of production plant and equipment are the responsibility of the supplier. The supplier shall supply to the purchaser a description of the manufacturing process.

The processes for curing, mould removal and handling conditions of the concrete sleepers and bearers are part of the manufacturing process. They shall be submitted to the purchaser for approval.

Any change in the manufacturing process shall be submitted to the purchaser for approval. The purchaser is entitled to verification that such changes will have no adverse effect on the concrete sleepers and bearers.

The concrete temperature shall be monitored.

When the temperature is measured in the concrete, it shall be measured as near as possible to the mid-depth and mid-width of the sleeper.

When the manufacturer can provide evidence of the relationship between concrete and air temperature at all stages throughout the curing cycle, it is permissible to measure the air temperature within the immediate curing environment instead the concrete temperature.

8.2.2 Manufacturing rules

Before starting production, the supplier shall complete a production file for manufacturing data, which shall be submitted in confidence to the purchaser and shall include the following:

- a) water/cement ratio and tolerance;
- b) weight of each component of concrete plus tolerance;
- c) grading curves for each aggregate of the concrete plus tolerance;
- d) properties of concrete after 7 days and after 28 days;
- e) maximum relaxation for prestressing tendons after 1 000 h according to ISO 15630-3;
- f) description of the prestressing system including prestressing force and tolerance on each tendon;
- g) methods of concrete vibration;
- h) curing time and temperature cycle;
- i) minimum concrete compressive strength before releasing prestressing tendons;
- j) method used for releasing prestressing force;
- k) stacking rules after manufacturing.

The sample sleepers submitted for design tests shall comply with the manufacturing data.

8.2.3 Curing

Curing is prevention against premature drying, particularly by solar radiation and wind. The curing method shall be approved by the purchaser.

Curing should start as soon as possible after the compaction of the concrete.

The principal measures for curing concrete are:

- a) keeping the formwork in place;
- b) covering with plastic films;
- c) placing of wet coverings;
- d) sprinkling with water;
- e) applying curing compounds which form protective membranes;
- f) high relative humidity.

The methods can be used separately or in combination.

Heat treatment, in addition to the heat of hydration, shall be allowed to increase the rate of early strength of the concrete.

Heat treatment can be used for:

- heat treatment of concrete in the mould;
- heat treatment of the fresh concrete before concreting.

Any change of the heat treatment shall be submitted to the purchaser for agreement.

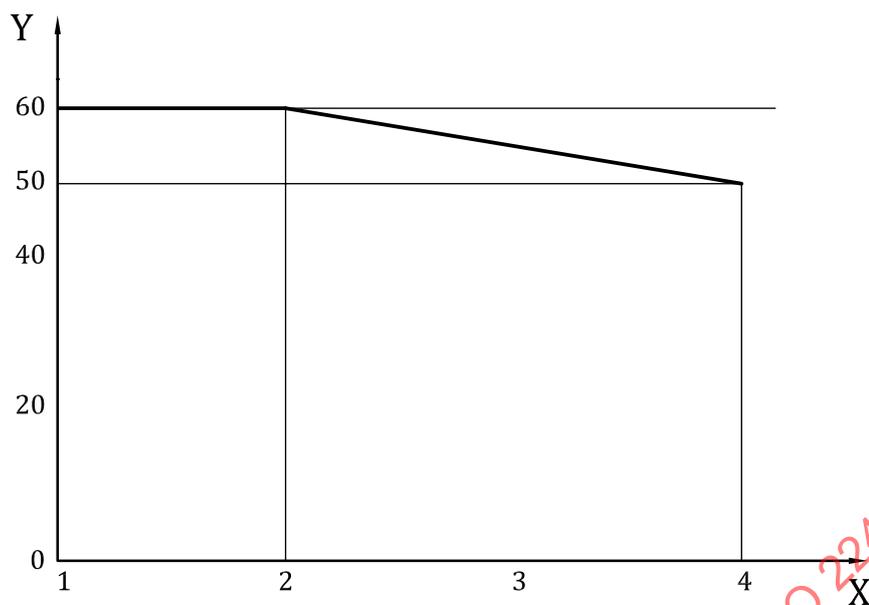
8.2.4 Concrete and ambient temperature

Concrete temperature and ambient temperature shall be controlled.

To avoid internal and surface cracking caused by heat generated in the concrete under normal conditions, the temperature difference between the centre and the surface of the concrete shall be less than 20 °C.

The maximum concrete temperature at the moment of compacting the concrete shall not exceed 35 °C.

In order to avoid delayed ettringite formation (DEF), the maximum permitted concrete temperature shall not exceed those shown in [Figure 4](#) and shall be reduced if the sulphur trioxide content of the cement expressed as a percentage of the cement by weight exceeds 2 %. [Figure 4](#) applies to ordinary Portland cement. If properly justified and agreed by the purchaser, higher maximum temperatures may be used.



Key

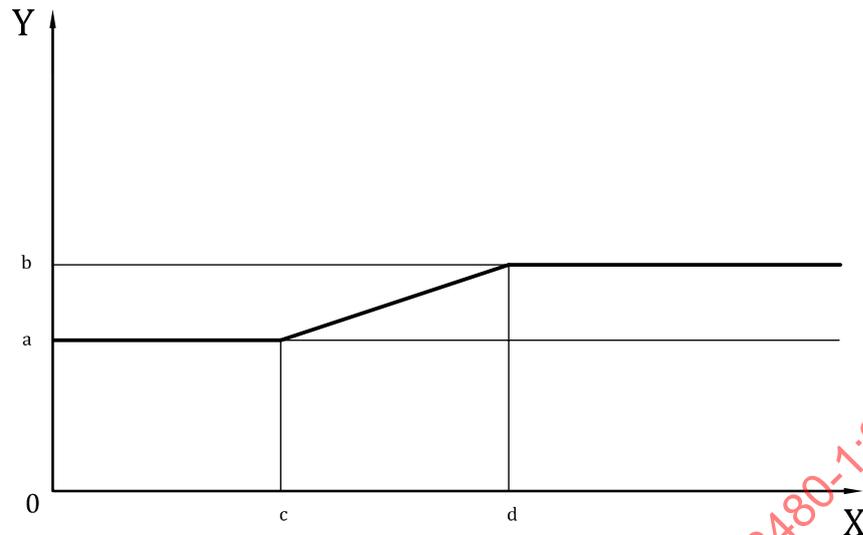
X sulphur trioxide (content of the cement % by mass)

Y concrete temperature (°C)

Figure 4 — Maximum curing temperature as a function of sulphur trioxide content in the cement

The ambient temperature shall be as shown in [Figure 5](#).

When applying accelerated curing by means of heating the mould directly, the temperature of the mould shall be as shown in [Figure 5](#).

**Key**

- X time after compacting
 Y ambient temperature (°C)
 a start temperature ≤ 35 °C
 b maximum ambient temperature ≤ 60 °C
 0 - c 3 h or preset time of concrete whichever is greater
 c - d increase period: maximum 15 °C/h and 10 °C/30 min, in any hour

Figure 5 — Maximum temperature curve ambient temperature

8.3 Surface finish

The top surface and sides of the concrete element shall have a uniformly smooth appearance. A random scattering of air holes is permitted on any surface.

For sleepers intended for ballasted tracks, the bottom surface shall be uniformly rough.

For sleepers on ballastless tracks, particular requirements for the bottom surface may be requested.

Particular attention shall be paid to the rail seat area, which shall be free of any individual large void.

The minimum requirement for finish to all surfaces shall be agreed between the purchaser and the supplier and shall be represented by samples and/or by photographs.

Remedial work on a concrete element after demoulding, which does not affect the mechanical performance of the product may only be carried out if detailed procedures have been included within the description of the manufacturing process.

An example for requirements on surface finish can be found in [Annex G](#).

8.4 Marking

Each concrete sleeper and bearer shall have the following permanent marking:

- a) year of manufacture;
- b) mould identification;
- c) identification mark of the production plant.

The purchaser may require additional information (permanent or not) to be identified on the concrete sleepers and bearers.

9 Product testing

9.1 General

This clause defines the testing regime and rules for acceptance of concrete sleepers and bearers.

Two kinds of tests are used:

- design approval test;
- routine test.

Bending tests for monoblock sleepers are defined in ISO 22480-2. For twin-block concrete sleepers, bearers and special elements, any relevant regional or national standard may be used.

The design approval test procedures are carried out on concrete sleepers and bearers selected according to a procedure agreed between the manufacturer and the purchaser.

The routine test procedures are carried out on concrete sleepers and bearers selected at random from the manufacturing production line. No additional preparation to normal production is allowed. Routine tests are usually assessed on a defined statistical basis.

Some railway networks use dual gauge and convertible gauge sleepers. In these cases, the test procedures in this clause may still be used but judgement shall be made by the purchaser on the combination of tests for two gauges.

9.2 Mechanical parameters

The following parameters are used in the tests defined in 9.3.

Occurrence of the first crack and measurement of crack width, as defined in Clause 4, are carried out at approximately 15 mm from the tensile face of the concrete element on both sides. Position of 15 mm is determined from the rail seat surface as detailed in Figure 6.

Dimension X is calculated with $X = h_p - 15$ (see Figure 1) or $X = h_r - 15$ (see Figure 2).

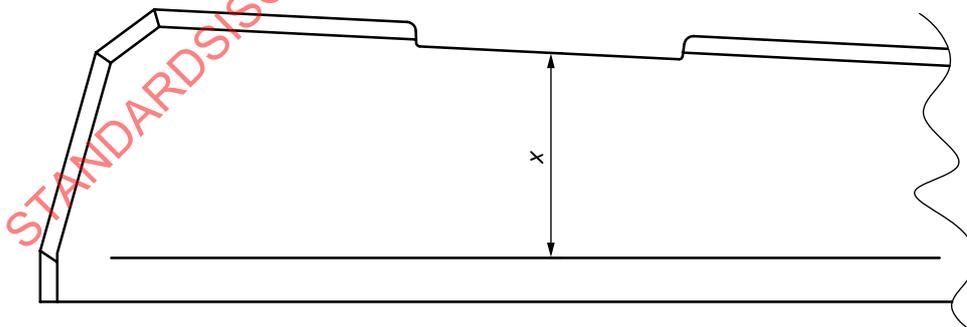


Figure 6 — Area for measurement of crack

For monoblock concrete sleepers, application of test loads is defined in ISO 22480-2. For twin-block concrete sleepers, bearers and special elements, any relevant regional or national standard may be used.

If there are requirements on crack width, it shall be measured using a graduated microscope of minimum magnifying power of 20 times to an accuracy of 0,01 mm.

9.3 Tests on product

The tests carried out are:

- a) static bending test: a static load condition to confirm the behaviour of a concrete sleeper or bearer; this test shall be carried out for design approval and routine tests;
- b) cyclic bending test: a cyclic load condition which applies a pulsating and increasing load to the concrete sleeper or bearer in order to simulate the effects of cyclic loads and impact loads in track; this is an optional design approval test carried out at the request of the purchaser;
- c) fatigue bending test: a cyclic load condition to simulate the loads applied to the concrete sleeper or bearer by traffic; this is an optional design approval test carried out at the request of the purchaser.

9.4 Tests on concrete

The tests to be carried out are:

- a) design approval tests of the concrete mix and routine tests of the concrete used;
- b) test on the properties of the concrete, in accordance with relevant regional or national standards.

9.5 Tests in combination with the fastening system

The tests to be carried out are:

- a) design approval tests, if required, which shall be defined by the purchaser according to relevant regional or national standards;
- b) electrical insulation design approval tests, if required, which shall be carried out according to relevant regional or national standards;
- c) routine test, if required, which shall be defined by the purchaser.

9.6 Additional tests

The following additional tests relating to the durability of the concrete may be required by the purchaser (depending on the environmental conditions):

- a) freeze-thaw resistance (method defined by the purchaser);
- b) water absorption of concrete at atmospheric pressure (see [Annex E](#));
- c) resistance to chloride penetration (method defined by the purchaser);
- d) abrasion properties of fine aggregates (method defined by the purchaser).

10 Quality control

10.1 General

The supplier shall operate a quality system, which is defined and maintained in a quality manual. This manual shall address all actions, functions and resources, procedures and practices concerned with achieving and providing documentary evidence that the concrete sleepers and bearers and the services provided by the supplier meet the agreed requirements.

The quality manual shall include a quality plan for the production of concrete sleepers and bearers, which defines and details the following:

- a) the organization, structure and responsibilities;

- b) all the materials, processes and procedures for manufacturing, storing and transporting of the concrete sleepers and bearers as described in the ISO 22480 series;
- c) all testing requirements including definition of testing equipment, method of testing, frequency of tests, etc.;
- d) all other quality control procedures to ensure and verify that the concrete sleepers and bearers and services provided are to the agreed requirements.

The purchaser shall have access to the quality manual at the premises of the supplier.

NOTE Guidance on quality systems is given in ISO 9000.

10.2 Quality control during design approval tests

The supplier shall provide to the purchaser all quality documents in relation with the concrete elements to be submitted to design approval tests.

This includes:

- a) detailed drawings of the concrete element and components included;
- b) detailed information of the anchoring system for prestressed elements;
- c) detailed information about concrete composition as mentioned in 7.6;
- d) procedure showing how all testing requirements are fulfilled; this includes:
 - 1) geometrical tests with description of the gauge and measurement method for each dimension;
 - 2) load tests on concrete and sleeper with the description of the measurement means and method;
- e) general description of the manufacturing process;
- f) test report showing compliance of the sleepers submitted to 9.3 with the dimensions and maximum tolerances defined in Table 1.

Design approval tests, results may be used for the determination of test loads to be used for routine tests, provided that they are done in the same test conditions.

10.3 Quality control during manufacturing

Before manufacturing, the supplier shall provide to the purchaser a quality plan including all quality documents in relation with the acceptance of materials and manufacturing of the concrete elements.

For routine tests, alternative test arrangements can be used if the manufacturer can provide evidence of results complying with approved test arrangements.

The quality plan shall detail:

- a) frequency of testing for each dimensional requirement;
- b) frequency for load tests on concrete and on sleeper or bearer;
- c) mechanism used to increase the inspection frequency when defects are identified;
- d) actions to be taken in the case of defects being found to ensure recheck for compliance.

In case of early dimensional inspection of the concrete element, the quality plan shall take into account further shortening of the element.

At the request of the purchaser, the supplier can be asked to carry out from time to time certain design approval test as part of the routine tests and confirm conformance with the requirements of this document.

Information for inspection frequency is given in [Annex H](#).

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Annex A (informative)

Determination of factor k_t for time dependent losses of strength

The flexural behaviour of a prestressed concrete sleeper or bearer depends essentially on the sectional modulus, the prestressing force and the flexural tensile strength of concrete. The last two parameters change during the lifetime of the sleeper or bearer.

The initial prestressing force, P_0 , decreases due to elastic shortening of the sleeper at the moment of transfer of prestress, steel relaxation, creep and shrinkage of the concrete, towards a final value. Design rules for these effects can be found in international or national standards or be determined by testing.

The flexural tensile strength, $f_{ct,fl}$, of concrete increases within the first weeks after production. During the following service phase, a continued loss of flexural tensile strength can appear due to repeated wheel loads and environmental impacts.

Both effects lead to bending capacity for first crack varying with time. The bending moments leading to first crack formation for sleepers and bearers after a short time after production are considerably higher than at the end of lifetime. Bending cracks shall not occur due to normal service loads during the entire lifetime of the sleeper or bearer. Therefore, the bending capacity for crack initiation of a sleeper or bearer tested shortly after production shall be considerably higher than the characteristic bending moment M_k in track.

Consequently, the characteristic bending moment M_k shall be increased to a test bending moment M_t in order to cover time-dependent losses during the lifetime of the sleeper or bearer in design approval tests. The test bending moment can be calculated with [Formula \(A.1\)](#):

$$M_t = M_k + [(f_{ct,fl,t1} - f_{ct,fl,t2}) - (\sigma_{c,P,t1} - \sigma_{c,P,t2})] \times W \quad (A.1)$$

where

- M_t is the test bending moment for first crack initiation (performance requirement);
- M_k is the characteristic bending moment due to actions in track;
- $f_{ct,fl,t1}$ is the flexural tensile strength of concrete at the moment of testing;
- $f_{ct,fl,t2}$ is the flexural tensile strength of concrete at the end of lifetime;
- $\sigma_{c,P,t1}$ is the stress in concrete due to prestressing force at the moment of testing (compression must be inserted with a negative value);
- $\sigma_{c,P,t2}$ is the stress in concrete due to prestressing force at the end of lifetime;
- W is the sectional modulus.

The ratio of M_t versus M_k shall be used as a factor k_t for the formulation of the acceptance criterion for first crack formation, that takes the age of the sleeper or bearer during testing into account.

Factor k_t can be calculated with [Formula \(A.2\)](#):

$$k_t = \frac{M_t}{M_k} \quad (\text{A.2})$$

Acceptance criterion for approval test, e.g. for the rail seat under a positive bending moment can be calculated with [Formula \(A.3\)](#):

$$Fr_r > k_t \times Fr_0 \quad (\text{A.3})$$

The factor k_t can be different for positive and negative test bending moments at the rail seat section and sleeper centre section, as it depends on sleeper geometry, prestressing force and the factor of utilization of the cross-section (the smaller the factor of utilization, the larger is k_t).

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Annex B (informative)

Calculation of the bending capacity by method A

The bending capacity for first crack formation M_{cr} of a prestressed concrete cross-section is calculated with [Formula \(B.1\)](#):

$$M_{cr} = (\alpha \times \sigma_{pi} + \beta \times f_{ctk}) \times W \quad (\text{B.1})$$

where

M_{cr} is the bending moment when the first crack appears;

α is the coefficient taking into account prestressing loss at the time of testing;

σ_{pi} is the concrete stress at the edge of the tensile zone due to the initial prestressing force;

β is the coefficient for concrete tensile strength;

W is the modulus of cross-section;

f_{ctk} is the design concrete tensile strength under normal stress at the time of testing.

The acceptance criterion for the static test is as follows:

- at the rail seat: $F_{rr} > k_t \times F_{r0}$;
- at the sleeper centre: $F_{crn} > k_t \times F_{c0n}$.

NOTE If the bending capacity M_{cr} is calculated with values of concrete strength and prestressing losses at the time of testing, the coefficient for time dependent losses is $k_t = 1,0$.

The required bending moment for ultimate strength is calculated with [Formula \(B.2\)](#):

$$M_u = \gamma \times M_{cr} \quad (\text{B.2})$$

where

M_u is the bending moment at ultimate strength;

M_{cr} is the bending moment when the first crack appears;

γ is the ratio between bending capacity for ultimate load and bending capacity for first crack formation.

For design approval test according to ISO 22480-2, the coefficient γ shall be taken as k_{2s} . Hence, the acceptance criterion for ultimate strength in the static test is as follows:

- at the rail seat: $F_{rB} > k_{2s} \times F_{r0}$;
- at the sleeper centre: $F_{cBn} > k_{2s} \times F_{c0n}$.

If required, the fatigue test load is calculated with [Formula \(B.3\)](#):

$$F_{\text{fat}} = q_{\text{max,fat}} \times F_{r0} \quad (\text{B.3})$$

The optional part of the fatigue test according to ISO 22480-2:2022, Figure 10 is not to be performed.

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Annex C (informative)

Determination and application of minimum performance requirements and related test loads from experience in track for method B

C.1 General

Loads from railway vehicles show a large scatter depending on track stiffness and maintenance level of rolling stock and track. Due to dynamic increase of the wheel loads and resonance phenomena, the effect of railway traffic loads on the sleepers or bearers cannot be described by simple mechanical models suitable for ordinary design calculations. In addition, the track as an assembly of elastic components, ballast and subsoil shows non-linear elastic behaviour in combination with settlement of the ballast. The mechanical properties of the track can only be simulated by complex numerical models.

Therefore, railway sleepers have been developed in the past by testing in track and stepwise improvement of the sleeper design.

If analytical models are not available, design requirements can alternatively be found by measurement in track and laboratory testing of sleepers that showed satisfying behaviour in track during a test phase of several years under heavy traffic load. In the 1980s, a research program was carried out by the International Union of Railways (UIC) in order to determine the bending capacities of railway sleepers used in European railway networks. The test program and the results are documented in report D170/RP 4:

project D170	Track component dimensions Standardization of characteristics and acceptance tests
report RP 4	Studies of different values which need to be taken into account with respect to the definition of the properties of concrete sleepers, and comparison of current testing methods. Determination of a unified test method and formulation of recommendations

The bending capacities found by testing with various bending test arrangements for static, cyclic and fatigue loading can be considered as an upper boundary for minimum performance requirements for railway sleepers. By applying these upper boundaries in the sleeper design process and in design acceptance tests of new sleeper types, these new sleepers should be as good as the existing sleepers in track, i.e. the new sleeper types should also show satisfying mechanical behaviour in track.

This design method has been integrated as the empirical method in EN 13230-6.

C.2 Loads on sleepers and bearers in track

Railway sleepers and bearers are subjected to repeated loads in three different directions, generally applied simultaneously:

- a) vertical loads from axle load and service conditions;
- b) transverse loads from guiding forces;
- c) longitudinal loads from acceleration and braking, thermal stresses in continuous welded rail, etc.

The static wheel load can be higher than the nominal wheel load due to, for example:

- overloaded vehicles;
- transverse wind pressure;
- cant deficiency which occurs when a train travels around a curve at a speed higher than the equilibrium speed. It is the difference between the theoretical cant required for such higher speed and actual cant provided.

The wheel-rail-contact force can be increased due to, for example:

- out-of-roundness wheels;
- railhead defects or corrugation;
- levelling faults of track;
- unwelded rail joints.

The longitudinal distribution of the load can deviate from the result predicted by a linear elastic design model like the elastic beam on elastic support due to, for example:

- support faults, e.g. voids under single sleepers;
- the elastoplastic behaviour of ballast and subsoil;
- wear of the rails;
- unwelded rail joints.

In addition, high loads can act on the sleeper due to exceptional or accidental loads, for example:

- large wheel flats;
- rail breaks;
- uplift of the ballast at the sleeper centre due to frozen ballast (“dancing” sleepers);
- derailed vehicles.

The bending moments in the sleepers due to the rail seat load can vary due to, for example:

- uneven distribution of the ballast reaction under the sleeper;
- dynamic or resonance effects due to dynamic rail seat loads.

Most of these effects are difficult to describe by mechanical models. Therefore, accurate load models for railway loads do not exist in design codes.

C.3 Consideration of loads in design of sleepers and bearers

Loads due to rail traffic shall be taken into account for design and testing of sleepers or bearers with regard to the three different load levels defined in [5.2.1](#).

a) Normal service dynamic loads

The sleeper or bearer shall be designed to withstand these loads without reduction of functionality during service life. In prestressed sleepers or bearers no bending cracks shall occur at this load level during service life, whence time dependent losses of prestressing force and concrete strength shall be taken into account in design and calculation of test loads. Some purchasers accept formation of bending cracks at the centre part of sleepers at this load level. In this case, residual crack width and fatigue shall be checked according to a method agreed by the purchaser.

b) Exceptional loads

The sleeper or bearer shall be designed to withstand these loads without reduction of functionality, however the formation of bending cracks is accepted for prestressed sleepers or bearers. Any crack shall be closed after removal of the load in order to avoid corrosion of steel reinforcement or prestressing elements.

c) Accidental loads

The sleeper or bearer shall be designed to withstand these loads without reduction of functionality of track. However, durability (i.e. resistance against failure due to corrosion or fatigue) can be reduced significantly.

The design of the sleeper or bearer shall be based on suitable characteristic values M_k of the bending moments under regular maintenance conditions. These characteristic bending moments, M_k , are related to the normal service dynamic load level. They can be determined by:

- calculation;
- measurement in track;
- testing of sleepers without bending cracks after several years in track. The test bending moment leading to first bending crack formation is an upper boundary for the characteristic bending moment in track.

C.4 Determination of minimum performance requirements by sleeper testing

Sleepers and bearers shall be tested after several years in service in bending tests as defined in ISO 22480-2 in order to determine the bending capacities for various mechanical failure modes of prestressed concrete beams. The bending tests shall be laid out to identify the bending capacities and the dominant failure modes for different load levels under static or repeated loads as described in C.5.

Once identified, these bending capacities can be used as acceptance criteria for design approval tests.

C.5 Calculation of test loads for design approval tests

The calculation of test loads and acceptance criteria for bending tests is based on characteristic bending moments M_k and coefficients k for the different load levels and frequency of occurrence of these loads. The initial reference test loads, F_0 , for all bending tests defined in ISO 22480-2 shall be calculated from the characteristic bending moments M_k which shall be used as M_0 .

The test methods and test loads are related to the failure modes of reinforced or prestressed concrete sleepers or bearers as follows.

a) First crack formation due to normal service dynamic load – failure of concrete under repeated flexural tensile stress

The initial reference test load F_0 shall be increased by a coefficient k_t in order to take time-dependent losses of prestressing force and tensile flexural strength of concrete under repeated loads into account. The test load for a static bending test shall be $k_t \times F_0$.

b) Yielding of reinforcement or prestressing steel – residual crack with crack width >0,05 mm due to a single exceptional load

The initial reference test load F_0 shall be increased by a coefficient k_{1s} in order to take the exceptional load level into account. The test load for a static bending test is $k_{1s} \times F_0$.

NOTE Experience in track shows that a remaining crack width $\leq 0,05$ mm when unloaded provides sufficient protection of steel reinforcement or prestressing elements against corrosion.

- c) Failure of steel or concrete – ultimate load due to accidental load

The initial reference test load F_0 is increased by a coefficient k_{2s} in order to take the accidental load level into account. The test load for a static bending test is $k_{2s} \times F_0$.

- d) Failure of bond between concrete and reinforcement or prestressing element – residual crack with crack width $>0,05$ mm due to repeated exceptional loads

The initial reference test load F_0 shall be increased by a coefficient k_{1d} in order to take the exceptional load level into account. The test load for a cyclic bending test is $k_{1d} \times F_0$.

- e) Low cycle fatigue failure of steel or concrete – ultimate load due to repeated exceptional loads

The initial reference test load F_0 is increased by a coefficient k_{2d} in order to take the exceptional load level into account. The test load for a cyclic test is $k_{2d} \times F_0$.

- f) Failure of bond between concrete or prestressing element due to repeated loads after first crack formation – crack width $>0,10$ mm when loaded or residual crack with crack width $>0,05$ mm due to normal service dynamic loads

The initial reference test load F_0 shall be increased or decreased by a coefficient $q_{\max, \text{fat}}$ in order to adapt the fatigue load to the number of load cycles in the fatigue test with respect to the load spectrum in track. The test load for a fatigue bending test is $q_{\max, \text{fat}} \times F_0$.

NOTE Experience in track shows that a crack width $\leq 0,10$ mm when loaded or a residual crack width $\leq 0,05$ mm when unloaded provides sufficient protection of steel reinforcement or prestressing elements against corrosion.

- g) Reduction of tensile strength of steel or compressive strength of concrete due to fatigue loading – ultimate load after repeated normal service dynamic load

The initial reference test load F_0 is increased by a coefficient k_3 in order to take the accidental load level into account. The test load for a fatigue test is $k_3 \times F_0$.

Annex D (informative)

Correspondence between relevant regional or national standards

This document refers to regional or national standards. [Table D.1](#) shows standards and additional specifications applicable in China, Europe and Japan that are relevant for individual topics referenced in this document. In other countries or regions other standards may be applied.

Table D.1 — Relevant regional or national standards and additional specifications

Reference in this document	Topic	Relevant CN standard or specification	Relevant EN standard or specification	Relevant JIS standard or specification
Introduction	Additional parts of series	GB/T 37330 TB/T 1878 TB/T 1879	EN 13230-3 EN 13230-4 EN 13230-5 EN 13230-6	
5.2.3	Characteristic bending moments	N/A	EN 13230-6	
5.3.2	Bending capacity	GB 50010	EN 1992-1-1	
5.3.3	Coefficients k_1, k_2, k_3	N/A	EN 13230-6	
6.2 f)	Coefficients k_t, k_1, k_2, k_3	N/A	EN 13230-6	
7.1 a)	Na ₂ O equivalent	TB/T 3275	EN 197	JIS R 5210
7.1 b)	Additions	TB/T 3275	EN 206	JIS R 5210
7.1 c)	Reactive alkalis	TB/T 3275	EN 206	JIS R 5210
7.2	Cement	TB/T 3275	EN 197-1 Use of Portland cement type CEM I is recommended. Cement other than type CEM I shall only be used if the durability of the sleepers can be demonstrated and approval is obtained from the purchaser.	JIS R 5210
7.3	Aggregates	TB/T 3275	EN 12620	JIS A 5308 Annex A JIS A 5005
7.4	Mixing water	TB/T 3275	EN 1008 shall be used unless a specific criterion is not within its scope, in which case national standards shall be used	JIS A 5308 Annex C
7.5	Admixture	TB/T 3275	EN 934-2 shall be used unless a specific criterion is not within its scope, in which case national standards shall be used	JIS A 6204
7.6.1	Concrete	TB/T 3275	EN 206 a) minimum strength class for concrete is C45/55	JIS A 5308